

"On the structure and affinities of the Tabulate Corals of the Palæozoic Period." By Dr. H. Alleyne-Nicholson. 8vo, 1879. From Professor W. J. Stephens, M.A.

"Science." Volume III., Nos. 45 to 48. From the Editor.

"The Victorian Naturalist." Vol. 1, No. 1, January 1884. From the Field Naturalists Club of Victoria.

"Memoir and Correspondence of Sir J. E. Smith, F.R.S., &c." 2 Vols., 8vo., 1832. From Thomas Whitelegge, Esq.

PAPERS READ.

A MONOGRAPH OF THE AUSTRALIAN SPONGES.

BY DR. R. VON LENDENFELD.

I.—INTRODUCTION.

During the two years I have spent in the colonies for the purpose of investigating the Coelenterata of our shores, I have collected and studied a great many sponges. I was entrusted with the identification of the sponges belonging to the Museums in Dunedin, Christchurch and Adelaide; and I perform a pleasant duty in thanking the Directors, von Haast, Haake and Parker, for the great liberality with which they assisted me in obtaining the specimens and information which I sought for.

The material and experience at my disposal would probably have remained obscure and useless had it not been for our Hon. Secretary, Through the well-known generosity of the Hon. W. Macleay, I shall be enabled to work out my subject exhaustively, and lay before the scientific world an extensive Monograph on my subject. Taking as a model O. Schmidt's "Spongien des Adriatischen Meeres."

THE NAME.

The word "Sponge" is derived from the Greek *σπογγία* which name was accepted by the Romans without an alteration : *Spongia*. The same root *σπογγ* is met with in most languages : *sponge*, *spongea*, *spyng*e Anglo-saxon, *spunge* Old English, *sponge* English, *spongie* Old Hollandish, *spons* Hollandish, *esponge* Old French, *éponge* French, *spogna*, *spogna* Italian, *esponga* Spanish, *esponja*, *esponga* Provence. The German *schwamm*, Old German *schwunnu*, and the Norwegian *Swamp* are not related to the Greek word. The same is the case with the Russian *gubak*, Hebrew *ekba* and Chaldaic *Akuba*.

Before entering into our subject, I shall give a brief account of our knowledge of the sponges, and cite the most important works on the subject, so as to enable any one of my readers who might wish to study the sponges, to find the references he requires.

It is always interesting to know, how any special science or branch thereof, has been developed, and I shall therefore give a short historic introduction,—an Embryology of Spongiology.

HISTORY OF OUR KNOWLEDGE OF THE SPONGES.

I.—FROM ARISTOTELES TO BELON, 350 a.C.—1553. CLASSICAL PERIOD.

As in nearly every other branch of Natural Science, so we find also here the first scientific description of Sponges in Aristoteles (384—322 a.C.) He described three species of *Ceraospongiæ* (1) "*ἔστι δὲ τῶν σπόγγων τρία γένη, ὁ μὲν μανός, ὁ δὲ πυκνός, τρίτος δ' ὃν καλοῦσιν Ἀχίλλειον λεπτότατος καὶ πυκνότατος καὶ ἰσχυρότατος*"

The three sponges referred to by Aristoteles, doubtless belong to the family of the *Spongiidæ* of F. E. Schulze (2).

(1). Aristoteles. *περὶ ζώων ἱστορίας*. Liber V., Cap. 16., § 76.

(2). F. E. Schulze. *Ueber den Bau und die Entwicklung der Spongien*, VII. *Die Familie der Spongiidæ*. *Zeitschrift für wissenschaftliche Zoologie* Band, XXXII.

Besides these, Aristoteles describes (3)., another genus, which according to O. Schmidt (4). is a *Sarcotragus* O. S. ; *ἔστι δ' ἄλλον γένος ὃν καλοῦσιν ἀπλυσίας διὰ τὸ μὴ δύνασθαι πλύνεσθαι.*" Aristoteles mentions that the sponges contract in rough weather, so as not to be torn from the rocks by the breakers. Because they are covered with dirt when brought to the surface, he thinks that they live on organic substances, which fall on them by chance. He knew that sponges can be propagated by cuttings, a subject we shall have to dwell on in detail further on. At least he mentions that sponges, which have been broken off grow out again (5). He thought that the sponges were animals and not plants, which appears evident from the fact that he lays great stress on their *similarity to plants*, which of course he would not do if he thought that they *were* plants.

Aristoteles is the only man of the ancient time whose writings on this subject are worth recording. Plinius (6), (23—79, p. C.), Dioscorides (7), and Claudius Aelianus (8), (about 180, p. C), only copied Aristoteles' works without mentioning his name. They add to the correct statements of Aristoteles a lot of foolish myths.

PRESENT TIME.

II.—FROM BELON TO GRANT, 1553—1826.

During the dark time of the middle age when the Church prosecuted and burnt all men of science, no one attempted to augment our knowledge of Biology, so that we have to pass over those ages which are a stain to humanity, from the old Aelianus 180, p. C, to Wotton, 1552, without being able to record a single paper on our subject.

Full 1400 years passed away without leaving any trace in history of our knowledge of Spongidae.

(3.) Aristoteles. *περὶ ζώων ἰστορίας*. Liber V., Cap. 16, § 80.

(4.) O. Schmidt. *Die Spongien des Adriatischen Meeres*, Seite 35.

(5.) Aristoteles. *περὶ ζώων ἰστορίας*. Liber V., Cap. 16, § 77.

(6.) Plinius Secundus C. *Historia Naturalis*. Liber IX., Cap. 45.

(7.) Dioscorides P. *περὶ ὕλης ἱατρικῆς* Liber V.

(8.) Aelianus Claudius, *περὶ ζώων*. Liber VIII. Cap 16.

The earliest writings of the present era are those of Wotton (9) (1552), and Belon (10) (1553). Both of these copied Aristoteles' writings. I will not trouble the reader with a list of the names, the bearers of which wrote on Sponges at the end of the sixteenth and beginning of the seventeenth Century, some declaring them to be animals, others to be plants, and others again taking them for concentrated spray (Gerarde (11) (1633). There is a great similarity between Aphrodite and a sponge !

Of greater interest to us appears an essay of Nieremberg (12) (1635), in which for the first time we find an *Australian* Sponge mentioned. He says that the Hindoos call an Australian Sponge Amacpalli: "Amacpalli seu manum coccineam appellat Indi quoddam Spongiæ marinae genus in *Australi* pelago."

In Ray's (13) (1686) works, we find eight species of sponges described, which together with some Corals (*Alcyonium*), are placed among the fungi as "Plantæ imperfectæ." At that time the sponges were considered as plants, and we find several authors placing them in the vegetable kingdom.

One of these authors, Tournefort (14), describes the sponges with the following diagnosis: "Herbæ marinæ aut fluviatiles, quarum flores et fructus vulgo ignorantur." Also the famous Anthony von Leeuwenhoek (15), appears to have held similar opinions. Carl von Linné (16), shared at first the error of his contemporaries, and described the sponges as Cryptogamic plants.

(9). E. Wotton. *De differentiis animalium*. Liber, X.. Parisii, 1552.

(10). P. Belon. *De Agustibus*. Liber II. Parisii, 1553.

(11). T. Gerarde. *The Herball*. London, 1633.

(12). T. E. Nieremberg. *Historia Naturæ*. Antverpiæ, 1635. Liber XIII. Cap. XXXII., p. 292.

(13). T. Ray. *Historia plantarum* Londini, 1686, 1693, 1704, and *Synopsis meth. stirp.* Britann. Londini, 1690.

(14). T. P. Tournefort. *Institutiones rei herb.* Vol. I. Parisiis, 1700.

(15). A. von Leeuwenhoek. *Microscopical observations*. Philosophical Transactions. XXIV. (1706), p. 2158.

(16). Carl von Linné. *Flora Lapponica*, Amstelædami, 1737, and *Hortus Clifort.* Amstelædami, 1737.

An essay of a much higher scientific standing than any of those mentioned above, and where we for the first time meet with higher philosophical ideas, was published by Donati (17), in 1750.

According to Donati, there exists in nature a *continuous series* of living beings, so that the animal and vegetable kingdom are not separated. In his book he lets the "Polipari" containing the sponges follow on the plants, they form the "primo grado con cui la Natura fa passaggio in Mare dalle Piante agli Animali."

The second grade are the "Piantanimali," which are divided into three groups.

He describes some sponges very accurately, and mentions for the first time the existence of *spicules*, "spine . . . di sostanza d' osso." Rumpf (18), describes some sponges from the Banda sea, but it is not possible to identify them with our North Australian sponges with any certainty. Only one, his "*Nidus vesparum marinus*" I shall probably be able to identify with one of them.

After Peyssonel (19) and others had been induced by worms and other animals, which sometimes live in sponges, to believe that they were *produced* by these commensales, Ellis (20) examined living sponges in an Aquarium, and discovered that these animals had nothing to do with the sponge, and that the sponges were animals *sui generis*.

Besides this, Ellis (l.c.) discovered, that currents of sea water passed through the body of the sponge; "when we examined these in glasses of sea water, we could plainly observe these little tubes to receive and pass the water too and and fro." These openings he took for the mouths of the sponge. There is therefore no doubt that he is the discoverer of the Pores and Oscula, and their functions.

(17). V. Donati. *Della storia naturale marina dell' Adriatico*. Saggio. Venezia, 1750.

(18). G. E. Rumpf. *Herbar. Amban. Tom. VI*. Amstælodami, 1750.

(19). T. A. Peyssonel. *New observations on the worms that form sponges*. Philosophical Transactions. Vol. L., 2 (1758), p. 590.

(20). T. Ellis. *On the Nature and formation of Sponges*. Philosophical Transactions. Vol. LV. (1766) p. 280.

Our knowledge of the species of sponges was greatly increased by Pallas (21). He describes 28 species of sponges, as belonging to the genus *Spongia*, and there are also some sponges in his genus *Alcyonium*. He accepts Ellis's discoveries as correct, and places the sponges—doubtless animals—under the Zoophyta, genus *Spongia*. “Animal ambiguum crescens, torpidissimum. Stirps polymorpha, e fibris contexta, gelatina viva obvestitis. Oscula oscillantia (?) seu cavernæ cellulaeve superficiei.”

In the twelfth edition of Linné's (22) *Systema Naturæ*, the sponges are for the first time described as animals.

Several species of sponges are described by authors of this period without advancing our knowledge of the Anatomy and Physiology at all.

After Ellis's death, Solander set to work to publish the papers of Ellis, but he also died over the work, which was then taken in hand by Ellis's daughter. In this book (23), Ellis's and Solander's discoveries are united to a whole. It contains a lot of valuable information.

Alcyonium and *Spongia* which have hitherto been considered very nearly related, or even to be the same, are strictly separated.

The genus *Spongia* is defined in the following manner: “Animal, fixum, flexile, polymorphum, torpidissimum, contextum vel e fibris reticulatis, vel e spinulis, gelatina viva vestitis; osculis seu foraminibus superficiei aquam respirans.”

Esper (24) and Olivi (25), who devoted much time and trouble to the sponges, did not render so much service to our Science as their English contemporaries.

(21). P. S. Pallas. *Elenchus Zoophytorum*. Hagae Comit., 1766.

(22). Carl von Linné. *Systema Naturæ*. Ed. XII. Vol. 1, 2. Holmiae, 1767.

(23). T. Ellis and D. Solander. *Natural History of many curious and uncommon Zoophytes*. London. 1786.

(24). Esper. *Die Pflanzenthierie and Fortsetzung der Pflanzenthierie*. Nürnberg, 1791—1806.

(25). L. Olivi. *Zoologia Adriatica*. Bassana, 1792.

De Lamarck (26), who deserves our attention as a general Biologist through his work "*Philosophie Zoologique*," in which he expounded our present ideas of the variability of species, and of the descent of one form of animal life from another; also devoted some of his energy to the sponges. In his "*Système des Animaux sans Vertèbres*," he describes and figures 54 species, but unfortunately also he mixes the sponges up with the Alcyonarians. He believes, namely, that all sponges possess polypes, and that it is only in consequence of deficient observation, that they had not been seen in all species, he goes so far as to call the sponges "Polypiers."

Lamouroux (27) already describes 168 species, and he, although copying Lamarck in many respects, states that the sponges are very, and fundamentally different from the Alcyonarians. His work is the best of the time.

Cuvier (28) treated the sponges very superficially, and without taking any notice of the former works of Ellis, Solander, Lamarck, and Lamouroux.

Of greater importance is A. T. Schweigger's (29) essay on sponges. He was the first to use the anatomical structure for classificatory purposes, and to point out the difference between calcareous and other sponges. The prevailing opinion of his time, that sponges contain polypes, which had as yet not been discovered, he treats ironically, although in consequence of the deficient methods of his time he is of course not able to prove their non-existence. He also observed the movements of the Oscula, which changed their diameter whilst he observed them.

T. E. Gray (30) considered the sponges as plants, and stated, that all sponges possess spicules. His observations were made on

(26). M. De Lamarck. *Histoire des animaux sans vertèbres*. Paris, 1816.

(27). T. Lamouroux. *Histoire des polypiers corallines flexibles*. Cæn, 1816.

(28). G. Cuvier. *Règne animal*. Vol. IV., 1817.

(29). A. T. Schweigger. *Beobachtungen auf Naturhistorischen Reisen*. Berlin, 1819, and *Handbuch der Naturgeschichte skelettloser ungliederter Thiere* Leipzig, 1820.

(30). T. E. Gray. *On the situation and rank of sponges in the scale of Nature*. Zoological Journal, I., 1824, p. 46.

Spongilla and a few other sponges from which he thought himself justified to conclude that all sponges were *Monactinellae*, in *Spongilla* he saw green bodies, and therefore considered it as a plant. A short time afterwards, and after his ideas had been adopted by several Zoologists, Gray changed his opinion and declared the sponges to be animals.

III.—FROM GRANT TO F. E. SCHULZE, 1826-1875.

Till Grant, so little was known about the Anatomy and Physiology of the sponges, that it appeared advantageous to review the papers of that period in their chronological order without reference to the contents.

In the period of progress initiated by Grant, a division of the papers under three headings becomes necessary, and we shall commence with the papers referring to the

ANATOMY AND HISTOLOGY

of the sponges. In this branch of Spongiology, we have now happily got over the dark age; and having worked our way through innumerable papers of little value, come to a series of publications, with which, as I can safely say, our knowledge of the sponges practically commences.

The author of these papers is R. E. Grant. He states that the sponges consist of a soft mass with or without a skeleton. This mass contains throughout ramified channels, through which water is continually passing. The water enters through small holes in the surface, Pores, and leaves the body of the sponge by means of the *Oscula*, which our author calls *faecal orifices*. The current of water runs always in the same direction, and is never reversed as former authors stated. He considered swinging cilia to be the cause of the current, although he did not observe them. He says that no classification of sponges is possible without the knowledge of their anatomical structure, and states that some sponges have a fibrous skeleton, consisting of horny fibre only, whilst in others,

spicules are contained in the fibres (31). He figures and describes the three forms of calcareous spicules (32). He observed the ova, the ciliated Embryo, and also, that this Embryo, after swimming about for some time, affixes itself (33).

He considers *Spongilla* to be nearly related to the siliceous marine sponges. (34.)

Like Lamarck, Grant (35) partly indulged in the views we now call "Darwinian."

Darwin says in his introduction to the "Origin of Species" that "Grant, in the concluding paragraph in his well-known paper on the *Spongilla*, clearly declares his belief that species are descended from other species and that they became improved in the course of modification."

Nardo (36) appears to have arrived at similarly sound conclusions as Grant, without knowledge of the latter's essays. Dujardin (37) discovered the amœboid movement of certain cells in sponges in 1838. Laurent (38) two years later described the propagation of *Spongilla* very minutely.

In this period we find Huxley's and Owen's names in the records of Spongiology, who, together with many other authors, are building up a good foundation for future work.

Dobie (39) discovered in 1852, the cilia on all the free surfaces of a calcareous sponge. We can trace the improvements of the

(31.) R. E. Grant. *Observations and experiments on the structure and function of the Sponge*, Edinburg, Philosophical Journal. Vol. XIII., and XIV.

(32.) R. E. Grant. *Remarks on the structure of some calcareous Sponges*. Edinburg. New Philosophical Journal. Vol. I.

(33.) R. E. Grant. *Observations on the spontaneous motions of the ova, etc.* Edinburg., New Phil. Journal. Vol. I.

(34.) R. E. Grant. *On the structure and nature of Spongilla fluviatilis*. Edinb. Phil. Journal. Vol. XIV.

(35.) R. E. Grant, (l c.). Vol. XIV., p. 283.

(36.) J. Nardo. *Classification der Schwämme*. Isis., 1833, 1834.

(37.) F. Dujardin. *Observations sur les éponges*. Annales des Sciences Naturelles, Tom X., 1838, p. 5.

(38.) T. Laurent. *Recherches sur la Spongille fluviatile*. Comptes rendus. Tome. XI., 1840, p. 1048.

(39.) W. Dobie. *Note on the observation of cilia in Grantia*. Ann. Mag. 1832. Vol. X., p. 317.



Microscope very clearly in the discovery of all the minute details in the anatomy of our animals.

In 1856, Lieberkühn (40) published an excellent paper on the development of spongilla. Afterwards Carter (41) wrote on the same subject, and without being acquainted with Lieberkühn's paper, arrived at nearly identical results.

Bowerbank (42) drew in 1858, attention to the great variety of the siliceous spicules in shape, particularly those anchorate and stellate forms, which we find in some of the siliceous sponges (*Stelletta* O.S., *Ancorina* O.S., &c.) He, as Grant had done before him, considered at that time the *shape* of the spicules as the principal thing to be considered in classifying the sponges. We shall find that he afterwards abandoned that idea to some extent, but that the recent researches of Zittel on fossil sponges show the correctness of it.

Lieberkühn (43) extended his observation to the marine sponges, and published in 1859, an excellent paper on their anatomy. He describes the canal system and the *ciliated chambers*, which, as we shall see, are peculiar and all important to the sponges.

Carter (44) arrived at the same time at very different results. He states that the ciliated chambers are not chambers as described by Lieberkühn, but *solid masses of cells which bear cilia on their external surface*, and he points out their similarity to *Volvox*. In another paper (45) he dwells on the similarity of the gemmule of *Spongilla*, to the winter ova of many simple algæ; and states that they contain starch granules.

(40.) N. Lieberkühn. *Beiträge zur Entwicklungsgeschichte der Spongillen*. Müllers Archiv., 1856.

(41.) H. Carter. *On the ultimate structure of Spongilla*, Ann. Mag. Vol. XX. (1857), p. 21.

(42.) Bowerbank. *On the Anatomy and Physiology of the Spongida*. Trans. Roy. Soc., Vol 148, p. 279.

(43.) Lieberkühn. *Neue Beiträge zur Anatomie der Spongien*. Archiv. für Anatomie und Physiologie, 1859.

(44.) Carter. Ann. Mag., Vol. III. (1859), page 12.

(45.) Carter. Ann. Mag., (1859), Vol. III., p. 331.

In 1860, Max Schultze (46) published a paper on Hyalonema, which at that time, when deep sea dredging was unknown, was very rare, and described it as the skeleton of a sponge affixed to the bottom of the sea by the long glassy threads which grow out from one extremity of it.

By many naturalists the Hyalonemas were considered as artificial products, made by the Japanese out of glass. Ehrenberg (47) held that opinion amongst others, and attempted to prove the inefficiency of Schultze's paper. In the subsequent controversy the animal nature of these Hexactinellid sponges was proved, although Ehrenberg himself never acknowledged that he had made a mistake.

With the year 1862 we enter into the modern and most fruitful period of the study of sponges, and we can safely say that everything published before that year, since Aristoteles, is not of such value as the discoveries made in every one of the years, from 1862 to 1884.

Bowerbank (48) publishes a series of valuable observations on the Anatomy of the sponges, and dwells in detail on the spicules, which are accurately figured and described.

Lieberkühn (49) continues his observations on Spongilla; among the important results of his investigations, I will mention the fact, that he thinks he has observed, that the ciliated Embryos of Spongilla sometimes multiply by fission, a statement of great importance.

Kölliker gives a preliminary notice of his histological investigations, in the same year. A full account of this most important

(46.) Max Schultze. *Die Hyalonemen, ein Beitrag zur Naturgeschichte der Spongien.* Bonn., 1860.

(47.) C. Ehrenberg. *Beiträge zur Beurtheilung der Gattung Hyalonema.* Monatsberichte der Akad. Berlin 1860, p. 173.

(48.) T. J. Bowerbank. *On the Anatomy and Physiology of the Spongiadae.* Phil. Trans. Roy. Soc. Vol. 148, p. 279. Vol. 152, p. 830. Vol. 152, p. 747. Vol. 152, p. 1082.

(49.) N. Lieberkühn. *Ueber Bewegungserscheinungen bei den Schwämmen.* Müllers Archiv., 1863. Seite, 717.

work (50) appeared two years later. Kölliker's observations on the Histology of the Sponges, can be considered as the foundation of our present knowledge of that subject. He discovered fibrous cells which he correctly considers as muscles. He pointed out that the horny skeleton of many sponges, as well as the calcareous and siliceous spicules are to be considered as productions of gland cells, and grow by apposition, a statement which has recently been proved by F. E. Schulze (51) and myself (52). He observed in many cases a cuticle on the surface of the sponges in continuity with, and of the same substance, as the horn fibres.

The correctness of this observation was doubted by F. E. Schulze (l. c.) I have been able (l. c.) to prove that Kölliker's statements on this point are perfectly correct, because, as we shall see hereafter, sponges attain such a cuticle, when sick; and it is highly probable that Kölliker had studied only sponges that had not been treated with the modern refinements of histological investigation.

F. E. Schulze's statement that such a cuticle does not exist is perfectly correct for the healthy living sponge, and for specimens treated in such a manner that they are killed before they have time to get sick.

O. Schmidt (53) published in 1865 his first supplement to the Adriatic Sponges, in which his views on the Histology are expressed. They differ from those of Kölliker.

Lieberkühn (54) dwells on the anatomical structure of the calcareous sponges. He described in 1865 the configuration of the canal system very accurately.

(50). A. von Kölliker. *Icones Histologicae*, 1. Abtheilung Protozoen Leipzig, 1869.

(51). F. E. Schulze. *Ueber den Bau und die Entwicklung der Spongien. Die Familie der Spongidae.* Z. f. w. Z. Band 32, Seite, 593.

(52). R. von Lendenfeld. *Calenteraten der Südsee II., Neue Aplysinidae.* Z. f. w. Z. Band 38. Seite, 234.

(53). O. Schmidt. *I. Supplement zu den Spongien des Adriatischen Meeres*, 1864.

(54). N. Lieberkühn. *Beiträge zur Anatomie der Kalkspongien.* Müller's Archiv., 1865, p. 732.

In the still continuing dispute between M. Schultze and Ehrenberg, about the root of Hyalonema, Bowerbank (55) enters with the statement, that the apertures (Cloaca) were to be found at the base of the sponge. He declares, namely, the Coral (Polythoa) which generally overgrows the Hyalonema, as part of the sponge, and considers the holes in it—where the Polypes had been situated—as the Oscula of the Hyalonema.

Haeckel (56) published in 1870 his observations “über die sexuelle Fortpflanzung und das natürliche System der Schwämme” where he describes the Spermatozoa, the fructification of the ovum and the early stages of development of the embryo.

CLASSIFICATION AND SYSTEMATIC POSITION.

Just as Grant opened up the Anatomy and Physiology, Johnston (57) laid the foundation for the classification. During twenty years his “History of British Sponges and Lithophytes,” was the main work of reference on our subject, and has only been surpassed by the recent monographs of Bowerbank and O. Schmidt. The excellent plates in this work were drawn by Mrs. Johnston. In this period we meet also with the first essays on sponges by Bowerbank (58) and Carter (59), the latter of whom is the Nestor among the present spongiologists. Carter was at that time surgeon in Bombay, and described some Indian fresh water sponges.

Leukart, (60) whose classical works in other branches of zoology make his opinion valuable, already in 1854 pointed out, that the

(55). T. Bowerbank. *Hyalonema mirabile*. Proc. Zool. Soc., 1867, p. 18' 350.

(56). Ernst Haeckel. *Ueber die sexuelle Fortpflanzung und das natürliche System der Schwämme*. Jenaische Zeitschr. VI. Seite. 641.

(57). G. Johnston. *History of British Sponges and Lithophytes*. Edin. 1842.

(58). J. S. Bowerbank. *Observations on a Keratous Sponge, from Australia*. Ann. Mag., Vol. VII. (1841), p. 129.

(59). H. T. Carter. *Notes on the species of the freshwater Sponges of Bombay*. Ann. Mag., Vol. I. (1848), page 303.

(60). R. Leukart. Archiv. für. Naturgeschichte, Band II.

sponges were related to the corals and hydroids, of course in a very different sense from that in which Lamarck and his contemporaries united them with the Alcyonarians. Although these views have been disputed ever since, all men of science of the present day nearly agree to the correctness of Leukart's statement. Huxley (61) at that time considered the sponges to be colonies of Protozoa, and called them "unicellular" organisms. In the sense which Huxley applies to the word "unicellular" all animals would have to be termed so, because all can be considered as colonies of simple cells—Protozoa.

In the same year Gray (62) described, among others, two sponges, *Carpenteria* and *Dujardinia*, which, according to Gray, hold an intermediate position between the sponges and the *Polythalamia*.

Lieberkühn (63) classifies the sponges according to the anatomy of their skeletons, and divides the whole of the sponges, in the way Grant had insinuated, into four groups: *Halisarcina*, without skeleton; *Spongina*, with a skeleton, consisting of horny fibre; *Calcispongina*, possessing spicules composed of carbonate of lime, and *Halichondria* possessing spicules composed of silica.

This classification has been adopted, more or less, by Bowerbank and O. Schmidt, and has been taken by Zittel, whose classification is now almost universally recognized, as the foundation of his own system.

In 1862, O. Schmidt (64) published his well-known "Spongien des Adriatischen Meeres," and described and figured very accurately a great many species from the Adriatic; since then for the last 22 years he has devoted all his time to the systematic description of sponges, and the study of their genetic relationships.

(61). T. Huxley. *Zoological notes and observations*. Annals and Magazine of Natural History, 1851, Vol. VIII., p. 370; 1851, Vol. VIII., p. 433.

(62). G. Gray. *Description of Aphroceros*. Proc. Zool. Soc., Vol. XXVI., p. 114.

(63). N. Lieberkühn. *Neue Beiträge zur Anatomie der Spongien*. Müller's Archiv., 1859, Seite, 353, 515.

(64). O. Schmidt. *Die Spongien des Adriatischen Meeres*. Leipzig, 1862.

The classification is the following :—I. *Calcispongiæ* (according to Grant—Lieberkühn.) II. *Ceraospongiæ* (Spongina Lieberkühn). III. *Gummineæ* (without continuous skeleton and tough like india-rubber, containing Nardo's Chondrosia). IV. *Corticatæ* (siliceous sponges, possessing as the term implies, an outer layer different from the interior of the sponge). V. *Halichondriæ* (according to Lieberkühn), and VI. *Halisarcina* (according to Lieberkühn).

In the same year appeared Bowerbanks (65) preliminary report on the Classification of the British Sponges, in which he adopts Grant's Classification. He calls the three groups: Calcarea, Silicea and Keratosa.

In 1864 appeared the first volume of Bowerbank's "Monograph of the British Sponges." (66).

The skeletons of many sponges are carefully described and many spicules are figured. He uses the classification published by him in the preliminary report mentioned above. The usefulness of this work is greatly impeded by the authors extraordinary neglect of other papers on the same subject. Several of the most important works on sponges, published shortly before, he does not appear even to have read.

Duchassing and Michelotti (67) described a number of new sponges from the Carribean Sea. Unfortunately they noticed neither the works of Bowerbank nor those of O. Schmidt, so that many of their species are identical with sponges described before.

Fritz Müller (68) discovered in 1865 an extraordinary sponge in South America, which possesses horny star shaped spicules. One of the species described by myself (69) from Australia

(65). T. Bowerbank. *On the Anatomy and Physiology of the Spongidaë*. Trans. Phil. Soc., 1862. Vol. 152, p. 10, 87.

(66.) J. Bowerbank. *A Monograph of the British Spongidaë*. Ray Soc., London, 1864.

(67). Duchassing et Michelotti. *Spongiaires de la mer Caraïbe*. Naturkundige Verhandlungen Maatschaappij Haarlam. XXI., 2 (1864), p. 7.

(68). F. Müller. *Ueber Darwinella aurea*. Archiv. für mikroskopische Anatomie Band, I. Seite, 344.

(69). R. von Lendenfeld. *Ueber Coelenteraten des Südsee II*. Neue Aplysinidæ. Zeitschrift f. wiss. Zool. Band. XXXVIII. Seite, 234.

contains fibres with a star shaped transverse section, and helps as I pointed out in the place cited above, to explain the otherwise unprecedented occurrence of such Keratous stars.

Up to 1866, all Zoologists had, with the abovenamed exception of Leukart, considered the sponges as Protozoa.

Amongst others, Huxley, O. Schmidt, and Kölliker. At the *Versammlung deutscher Naturforscher und Ärzte* at Hannover, in 1866, Van Beneden and Claus declared the sponges to be *Coelenterata* (70).

In consequence of Bowerbank not making use of previously published essays, a great confusion in the nomenclature arose. O. Schmidt therefore in his second Supplement (71) reduced the diagnoses of Bowerbank to his own names, and it is only with this key possible to understand Bowerbank's work.

In the same year appeared the second volume of Bowerbank's *Monograph* (72).

A year later Hancock (73) published a paper on excavating sponges, to prove that they were not as Bowerbank had stated, ordinary *Halichondriæ*, which lived in deserted worm tubes, and other old excavations, but that they bored these holes themselves.

In 1867, Selenka (74) published a paper on the sponges of the Southern Seas, where for the first time a number of Australian sponges are accurately described and figured. I have been able to identify several of our sponges with Selenka's species.

(70). *Amtlicher Bericht der Versammlung deutscher Naturforscher und Aerzte in Hannover*, 1866.

(71). O. Schmidt. *Zweites Supplement zu den Spongien des Adriatischen Meeres*. Leipzig, 1866.

(72). J. Bowerbank. *A Monograph of the British Spongiæ* Vol. II. Roy. Soc. London, 1866.

(73). A. Hancock. *Note on the excavating sponges*. *Ann. Mag.*, 1867, Vol. XIX., p. 229.

(74). E. Selenka. *Über einige neue Schwämme der Südsee*. *Z. f. wiss. Zool.* Band XVII. Seite, 565.

In 1868, two eminent Zoologists, Haeckel (75) and Miklouho-Maclay (76) tried to prove the correctness of Leukart's (l. c.) opinion, that the sponges are Cœlenterata.

Haeckel arrives at the opinion of the Cœlenterata-nature of sponges, by his extensive knowledge of a great many species; whilst Miklouho-Maclay (l. c.) was brought to this view of the subject by the intensive study of a single form *Guancha blanca*.

The most important point in this question, is the fact, that the sponges are developed like all higher animals from ova and Spermatozoa, and pass through a Gastrula stage, wherefore they must be strictly separated from the Protozoa.

It is Haeckel to whom the merit of pointing out this simple but all important fact is due.

Gray (77) published in the same year a classification of the sponges, which has not been accepted by the scientific world. He also describes several new species from Australia.

Bowerbank (78) criticised Gray's system rather sharply, and pointed out many doubtful statements in it.

In the same year, 1868, appeared O. Schmidt's (79) third Supplement to his Adriatic Sponges, in which the sponges of Algeria are described.

Some changes are made in the classification and new families are added.

One of these, the Chalcinea, is of interest to us, as nearly half of the Australian sponges belong to it.

(75). E. Haeckel. *Ueber die sexuelle Fortpflanzung und das natürliche System der Schwämme*. Jen. Zeitschr. VI., 641.

(76). Miklouho-Maclay. *Beiträge zur Kenntniss der Spongien I*. Jen. Ztschr., IV., 221. and *Ueber Schwämme des nördlichen stillen Oceans und der Eismeeres*. Mem. Acad., Petersbourg, XV., 3. Seite, 1.

(77). T. Gray. *Notes on the arrangement of sponges with the description of of some new genera*. Proc. Zool. Soc., 1867, p. 492.

(78). J. Bowerbank. *On Mr. Gray's arrangement of sponges*. Proc. Zool. Soc., 1868, p. 118.

(79). O. Schmidt. *III.tes Supplement. Die Spongien von Algier*.

Several smaller papers on new sponges, mostly English, were published at that time.

Bowerbank (80) and Claus (81) studied the Hexactinellid sponges, and particularly by the latter monograph of *Euplectella aspergillum* gives a correct and complete account of the skeleton.

Lovén (82) and others also worked on the same subject. As there are hardly any Hexactinellid (one) sponges on the shores of Australia, it is not worth while for us to enter into the history of their study more minutely.

The works of Haeckel (l.c.) created, after they had been translated into English, (83) I may say, a storm of indignation in England, and particularly in America, and a whole host of writers took up their pens to prove that Haeckel's and Miklouho-Maclay's views on the Cœlenterate-Nature of sponges were incorrect and ridiculous. Only Ray Lancaster (84) agreed with Haeckel.

Carter (85) and Kent (86) were foremost in the combat.

Also in Germany some opponents were found. Ehlers, (87) for instance, was not inclined to agree with Haeckel.

Ehlers (88) re-described the sponges which were studied by Esper.

In his most important work *Grundzüge einer Spongienfauna des Atlantischen Gebietes*, O. Schmidt (89) publishes the results

(80). J. Bowerbank. *Hyalonema mirabile*. Proc. Zool. Soc., 1867, p. 18, 350.

(81). C. Claus. *Ueber Euplectella aspergillum*. Marburg und Leipzig, 1868.

(82). S. Lovén. *Om en märklig i Nordijön lefvande Art af Spongia*. Oefversigt af Vetensk. Akad. förhändlgr XXV., p. 105.

(83.) E Haeckel. *On the systematic position of sponges*. Ann. Mag., Vol. V, 1, 107.

(84.) Ray Lancaster. *On the affinity of sponges*. Ann. Mag., Vol. VI., p. 80.

(85). H. Carter. *On the ultimate structure of marine sponges*. Ann. Mag., Vol. VI., p. 329.

(86). S. Kent. *Haeckel on the relationship of the sponges to the corals*. Ann. Mag., Vol. V., p. 204.

(87). E. Ehlers. *Ueber Aulorhipis elegans*, Z.f.w.Z., Vol. XXI., p. 540.

(88). E Ehlers. *Die Esperschen Spongien*. Programme Erlangen, 1870.

(89). O. Schmidt. *Grundzüge einer Spongienfauna des Atlantischen Gebietes*. Leipzig, 1870.

of his study of the Sponges in the Museums of Copenhagen and Cambridge Mass. His classification, which he calls "Descendenz-Systematic," is different to most of the former classificatory systems. He tries to form continuous series instead of describing distinct species, and so breaks with the old dogmatic idea of species.

O. Schmidt (90) also extends his identification of the Bowerbankian Sponges, so that only few of them retain their former incognito.

He now divides the sponges into four groups :—1. Sponges with hexaradiate spicules to which belong the fossil *Ventriculites*. 2. Sponges with anchor-shaped tetraradiate spicules related to the fossil *Vermiculates*. 3. Sponges with biradiate spicules to which belong the horn-fibred sponges, and those which possess no skeleton. 4. Calcareous Sponges.

This classification has recently been adopted and worked out in detail by Zittel, (91) who supported this classification by the results of his study of fossil forms.

A whole series of small papers of this period are again devoted to the *Hexactinellidæ*.

An important paper was published in 1871, by Miklouho-Maclay (92), on *Veluspa polymorpha*, a sponge belonging to O. Schmidt's *Chalinidæ*. A continuous series of different forms are described, which are not divided from each other by sharp boundary-lines, and at the ends of the series we meet with totally different forms.

The single individual varies to a great extent, and not even the shape of the spicules is constant. Size and colour vary very much, and different shapes of the whole are formed by different modes of concrescence of single zooids.

(90). O. Schmidt l c. Seite., 76.

(91). K. Zittel. *Zur Stammesgeschichte der Spongien*. München, 1878.

(92). Miklouho-Maclay. *Veluspa polymorpha*. Mem. Acad. Im , Petersb., 1870, Vol XV., p. 3.

It is remarkable that in the Australian waters, sponges corresponding to Miklouho-Maclay's descriptions are very common, and that this sponge is just as polymorphic here as Miklouho-Maclay's specimens from the White Sea. Among the thousands of Australian sponge individuals I have examined nearly the half correspond to *Veluspa* Miklouho-Maclay.

He also (l.c.) dwells on other sponges of varying shape.

In the same year Harting (93) described *Poterion*, the giant among sponges.

Carter (94) describes several new species.

In 1872, Pagenstecher (95) published a historical introduction to our knowledge of the spongida.

In the same year appeared Haeckel's Monograph of the Calcareous Sponges (96) in three volumes, with 60 plates. He hopes by the accurate study of one group of animals to render "den analytischen Beweis von der gemeinsamen Descendenz aller, einer solchen Gruppe zugehörigen Species."

This well-known work may be considered as a model of a scientific zoological book. The philosophical deductions are clever, often brilliant, the classification is simple and clear, and the plates show the artistic sense of the author.

The scientific facts contained therein are similar to those published previously by the same author.

Whilst this publication settled all doubt about the Coelenterate-nature of the sponges in Germany; English and American authors continue to publish papers to prove that the sponges are Protozoa. Carter (97) calls the cells in the walls of the ciliated chambers

(93). P. Harting. *Memoire sur de genre Poterion*. Naturk. Verhandl. Utrechtsch. Genoatsch 1870, p. 1.

(94). H. Carter. Ann. Mag. (Series 4), Vol. VIII, p. I; Vol. VIII., p. 99; Vol. IX., p. 409; Vol. XII., p. 349.

(95). H. Pagenstecher. *Zur Kenntniss der Schwämme I. Geschichtliche Einleitung*. Verhandl. Verein Heidelberg VI., 1872, Seite. 1.

(96). E. Haeckel. *Die Kalkschwämme* 3 Bände, Berlin, 1872.

(97). H. Carter. *Development of the Marine Sponges*. Ann. Mag., Vol. XIV., p. 321, 389.

Spongozoa, he observed that they copulated like Diffugia, and in this way sexual multiplication was attained. The embryos formed by the conjugation of two Spongozoa are developed in the canals. He observed (l.c.) that carmine particles were absorbed by the Spongozoa and digested by them, which he takes as a proof that these cells are really animals *κατ' ἐξοχήν*. According to that the epithelium of the intestine of higher animals which also absorbs carmine must likewise be considered as a colony of many separate animals. He comes to the conclusion that the ciliated chambers are more like Ascidians than Polyps. At the conclusion of another paper (98) he gives his view on the subject in the following words:—"The Spongozoan must, *ipso facto*, be considered the expression of the sponge, in so far, that it represents the stomach and the generative apparatus, aided by the rest of the body, which thus becomes analogous to such accessories in the highest animals, although the plurality of Spongozoa scattered through the mass may more nearly resemble in this respect the flower buds of plant, such then appears to be the nature of a sponge."

PALEONTOLOGY.

After our knowledge of the fossil sponges had been greatly increased by Goldfuss (99), de Blainville (100), made the first attempt to unite the fossil and recent sponges in one classificatory system.

Toulmain Smith (101) published in 1848, an excellent monograph of the cretacious Ventriculites. He describes the spicules very accurately. Regarding the systematic position of those Ventriculites he made a mistake. He declares them to be Polyzoa.

(98). H. Carter. *On the nature of the side-like body of Spongilla &c.* Ann. Mag., Vol. XIV., p. 97.

(99). G. Goldfuss. *Petrefacta Germaniæ*. Düsseldorf, 1826-1833.

(100). M. De Blainville. *Article Eponge*. Dictionnaire des Sciences Naturelles, 1819, Vol. XV.

(101). Toulmain Smith. *On the Ventriculidæ of the chalk*. Ann. Mag. Vol. XX., (1847), p. 73.

IV.—FROM T. E. SCHULTZE TO THE PRESENT DAY, 1875—1884.

In no branch of Biology has such an advance been made within the last ten years as in Spongiology.

The papers to be mentioned here shall be reviewed more briefly than the preceding ones, because we shall have to repeat their contents anon : we cannot write a history of a period which is not completed.

We shall have to divide the papers of this period into five groups, and shall commence as in the foregoing chapter with the Anatomy.

ANATOMY AND HISTOLOGY.

In a series of papers (102) Schultze describes very accurately many genera of sponges belonging to several different groups. His results are in the main features the following :—The sponges consist of three layers Ectoderm, Entoderm, and a third, which he hesitatingly calls Mesoderm.

The Ectoderm consists throughout of simple flat ciliated cells, which cover the outer surface of the sponge, and the walls of the canals through which the water flows from the outer surface to the ciliated chambers.

These ciliated chambers, together with the canals leading from thence to the Oscular tube, and also this tube, are covered with Entodermal cells, which in the chambers of the ordinary, and in the corresponding tubes of the calcareous sponges, have the shape of long, fringed and ciliated elements, whilst in the canal system they

(102). F. E. Schulze. *Ueber den Bau und die Entwicklung der Spongien*. Zeitschrift für wissenschaftliche Zoologie. Sycandra rayhanus Supplement, Band, XXXV., Seite, 247. Entwicklungsgeschichte von Sycandra. Band, XXVII., Seite, 486. Die Gattung Halisarca, Band, XXVIII., Seite, 1. Die Familie der Chondrosidæ, Band, XXIX., Seite, 87. Die Familie der Aplysinidæ, Band, XXX., Seite, 379. Metamorphose von Sycandra. Band, XXXI., Seite, 262. Die Gattung Spongelia, Band, XXXII., Seite, 117. Die Familie der Spongidæ, Band, XXXII., Seite, 593. Die Gattung Hircinia. Band, XXXIII., Seite, 1. Die Plakiniden, Band, XXXIV., Seite, 407. Corticium candelabrum, Band, XXXV., Seite, 410.

form a low ciliated Epithelium. The intermediate layer which forms the bulk of the sponge, consists of a soft gelatinous or harder cartilaginous substance, like the gallert of the umbrellas of the Medusæ, in which cells of different shapes are embedded. These cells are partly elongate, muscular, partly star shaped tissue cells, partly horn-producing, gland cells, ova, spermatophors, and so on.

Keller (103) and Metschnikoff (104) agree in the main points with Schulze.

Schulze (105) describes a new form of propagation of sponges, by floating polycellular buds.

Sollas (106) made experiments to show the influence of caustic potash on the spicules; he published a series of anatomical and histological researches, which contain a great many interesting facts, and are worthy of comparison with Schultze's classical works.

Also, Carter (107) published some data on the structure of sponges, but unfortunately without noticing the previous publications on the subject.

Schulze (108) published in 1881, a paper on the soft parts of Euplectella, from which we learn, that the Histology of this well-known sponge, corresponds with the minute structure of sponges belonging to other groups.

(103). O. Keller. *Untersuehung über die Anatomie und Entwicklungsgeschichte einiger Spongien des Mittelmeeres*. Basel, 1876. *Ueber den Bau von Reniera semitubulosa*. Z. f. w. Z., XXX., Seite, 563. *Studien über Organisation und Entwicklung der Chalcinen*. Z. f. w. Z., XXXIII., 317. *Neue Coelenteraten aus dem Golfe von Neapel*. Arch. f. mik. Anat. XVIII., 271.

(104). E. Metschnikoff. *Beiträge zur Morphologie der Spongien*. Z. f. w. Z. Band. XXVII., Seite, 275. *Spongiologische Studien*. Seite, 349.

(105). F. E. Schulze. *Ueber die Bildung freischwebender, Brutknospen bei einer Spongie Halisarea lobularis*. Zool. Anz. II., Seite, 636.

(106). Sollas. *Sponge fauna of Norway*. Ann. Mag (Series 5), Vol. V., p. 130. Vol. V., p. 241. Vol. V., p. 396. Vol. IX., p. 141. Vol. IX., p. 426.

(107). H. Carter. *Contributions to our knowledge of the Spongia II., Ceratina*. Ann. Mag., Vol. VIII., p. 101. *On the development of the fibre in the Spongia*. Ann. Mag., Vol. VIII., p. 112.

(108). F. E. Schulze. *Of the soft parts of Euplectella aspergillum*. Trans. Roy. S., Edinburgh., XXIX., p. 636.

Ray Lankaster (109) dwells on Chlorophyll and Amyloid deposits in *Spongilla*.

I published a short note on the growth of the Hornfibres of sponges (*Aplysinidæ*) (110).

Poléjaeff (111) dwells in detail on the Sperma und Spermatogenesis in *Sycandra raphanus*.

In another paper (112) I gave the results of my researches on three species of Australian *Aplysinidæ*.

Besides endorsing Schulze's discoveries, I was enabled to draw attention to some new facts concerning the structure of sponges. Gland cells producing a slimy covering on the surface of the sponges when in unfavourable circumstances, similar to those discovered by Merejkovsky (112a) in *Halisarca*, were described. The formation and growth of ova and spermatozoa were studied, and several doubtful points elucidated by my researches.

CLASSIFICATION AND SYSTEMATIC POSITION.

Continuing from page 141, we record the following papers on this subject.

Gray (113) publishes a classification of the sponges amended in another paper. (114).

(109). Ray Lankaster. *On the Chlorophyll-corpuscles and Amyloid deposits of Spongilla and Hydra*. Quart. J. Micr. Sc., Vol. XXII., p. 229.

(110). R. von Lendenfeld. *Das Hornfaserwachsthum der Aplysinidæ*. Zoologischer Anzeiger. Band V., Seite. 634.

(111). N. Poléjaeff. *Ueber das Sperma und die Spermatogenese bei Sycandra raphanus*. Sitzungsberichte der k. Akad. Wiss. Wien. Math. nat Classe I. Abth. 86, Band 3 5 Heft., Seite. 276—298.

(112). R. von Lendenfeld. *Ueber Cœlenteraten der Südsee. II. Neue Aplysinidæ*. Z.f.w.Z. Band XXXVIII., Seite. 234.

(112a). Merejkovsky. *Etudes sur les Epouges de la mer blanche*. Mem. de l'Acad. de Petersbg., 1878.

(113). J. Gray. *On the classification of Sponges*. Ann. Mag. (Series 4), Vol. XI., p. 442.

(114). J. Gray. *On the arrangement of Sponges*. Ann. Mag., Vol. XIII., p. 284.

Very different from this is Carter's (115) classificatory system. He divides the sponges, according to the structure of their skeleton, into 8 orders :—

- I. *Carnosa*, without evident skeleton.
- II. *Ceratina*. Possessing a skeleton composed of horny fibre, with a granular, chiefly hollow core, containing for the most part no foreign bodies.
- III. *Psammonemata*. Possessing a skeleton composed of solid fibre, more or less cored with foreign bodies.
- IV. *Raphidonemata*. Possessing a skeleton composed of horny fibre, with a core of proper spicules.
- V. *Echinonemata*. Possessing a skeleton composed of horny fibre, cored with proper spicules internally, and echinated with proper spicules externally.
- VI. *Holorhaphidata*. Possessing a skeleton, whose fibre is almost entirely composed of proper spicules, bound together by a minimum sarcode.
- VII. *Hexactinellida*. Possessing a skeleton composed of hexactinellid spicules.
- VIII. *Calcarea*. Possessing a skeleton composed of calcareous spicules.

Of Bowerbank's Monograph the third volume (116) appeared in 1874, in which new species are described, and some of O. Schmidt's sponges are compared with the author's descriptions.

In another series of papers (117) he describes a number of new species from all parts of the world. A great many of these are Australian.

(115). H. Carter. *Notes introductory to the study and classification of Spongida*. Ann. Mag. (Series 4), Vol. XVI., pp. 126, 127.

(116). J. Bowerbank. *A Monograph of the British Spongida*. Vol. III., Ray. Soc., London, 1874.

(117). J. Bowerbank. *Contributions to the general history of the Spongida*. Proc. Zool. Soc., Vol. 1872, p. 115; 1872, p. 156; 1872, p. 626; 1873, p. 3; 1873, p. 319; 1874, p. 298; 1875, p. 281; 1876, p. 768.

O. Schmidt (118) published a most important paper on the sponges of the Gulf of Mexico, where the views expressed by the same author in his paper on the Atlantic Sponge-fauna are carried out. The sponges described are throughout siliceous deep sea-sponges: Lithistidæ and Hexactinellidæ. In the preface we find some notes concerning Bowerbank, who, although being personally acquainted with O. Schmidt, seems to have remained ignorant of the contents of O. Schmidt's papers on sponges.

Hyatt (119) describes many new American sponges, mostly Ceraospongiæ.

It would lead too far to review here all the papers containing descriptions of new species, suffice it to note a few of the more important publications of this kind.

The most prominent authors in this field are the following:—Marenzeller (120), Carter (121), Higgin (122), Czerniavsky

(118). O. Schmidt. *Die Spongien des Meerbusens von Mexico*. Jena., 1878—80.

(119). A. Hyatt, *Revision of North American Porifera*. Mem. Bost. Soc., Vol. I., 1875, p. 399; Vol. II., 1877, p. 505.

(120). E. von Marenzeller. *Coelenteraten etc. der österreichischen Nordpol Expedition*. Deuschr. Akad. Wien XXXV.

(121). H. Carter. *Description and figures of deep sea sponges*. Ann. Mag., Vol. XVIII., 226, 307, 388, 458. *Arctic and Antarctic sponges*. Ann. Mag., Vol. XX., p. 38. *On Tedania*. Ann. Mag., Vol. II., p. 35. *Contributions to our knowledge of the Spongida*. Ann. M., Vol. III., p. 284, 343; Vol. VIII., p. 101, 241. *History and classification of the known species of Spongilla*. Ann. Mag., Vol. VII., p. 77. *Report on specimens dredged up from the Gulf of Manoa*. Ann. Mag., Vol. VI., p. 129. *Supplementary report on specimens, etc., from the Gulf of Manoa*. Ann. Mag., Vol. VII., p. 361. *Contributions to our knowledge of the Spongida*. I. *Carnosa*. Ann. Mag., Vol. VIII., p. 241. II. *Ceratina*. Ann. Mag., Vol. VIII., p. 101. *Addendum to our knowledge of the Carnosa*. Ann. Mag. (5), Vol. VIII., p. 450. *Some sponges from the West Indies and Acapulco*. Ann. Mag. (5), Vol. IX., p. 266, 346. *New sponges, observations on old ones and a proposed new group*. Ann. Mag. (5), Vol. X., p. 106. *New genus of sponges*. Ann. Mag. (5), Vol. XI., p. 369. *Contributions to our knowledge of the Spongida—Pachytrigida*. Ann. Mag. (5), Vol. XI., p. 344.

(122). T. Higgin. *Sponges dredged by the S.S. Argo in the Carribean Sea*. Ann. Mag., Vol. XIX., p. 291.

(123), Schultze (124), Sollas (125), Keller (126), Wyville Thomson (127), Marshall (128), Bowerbank (129), D'Urban (130), Dylowsky (131), Vosmaer (132), Ridley (133), Potts (134), Haswell (135), Lendenfeld (136), Chilton (137), Hilgendorf (138), Retzer (139), Vejdovsky (140).

Metschnikoff (141) dwells on the systematic position of the Spongiadae, and comes to the conclusion that their Embryology and Histology prove their relationship with the Hydrozoa, but that they are not so highly organised as these.

(123). W. Czerniavsky. *Spongiae littorales marium pontici et caspii*. Bull. Soc. Imp., Moscow, 1879-80.

(124). F. E. Schulze (l. c.)

(125). N. Sollas (l. c.)

(126). C. Keller (l. c.)

(127). Wyville Thomson. *The Voyage of the Challenger*, London, 1878.

(128). W. Marshall. *Ideen über die Verwandtschaftsverhältnisse der Hexactinelliden*. Z. f. w. Z., Band, XXVII., p. 113. *Untersuchungen über Dysideiden und Phoriospongien*. Z. f. w. Z. Band, XXXV., p. 88. *Ueber einige neue Kieselschwämme aus dem Congo*. Jen. Zeitsch. Band XVI., p. 553.

(129). Bowerbank (l. c.), *Monograph of the siliceo-fibred sponges*. Proc. Zool. Soc., 1875, p. 272; 1875, p. 503; 1875, p. 558; 1876, p. 535. *A Monograph of British Spongiadae*, Vol. IV. Ray. Soc., London, 1881.

(130). W. D'Urban. *The Zoology of the Barents Sea*. Ann. Mag. (5). VI., p. 253.

(131). Dylowsky. *Studien über die Spongien des russischen Reiches etc.* . Mem. Acad. Imp. Petersb., VII., Serie, XXVII., No. 6.

(132). G. Vosmaer. *The Sponges of the Leyden Museum*. I. Notes from the Leyden Museum, II. Note 13, 99. *Voorlap Bericht antrent het onderzock Werktafel in het Zool. Stat. de Naples*. Report on the sponges dredged up in the Arctic Sea by the "Willem Barrents." Nederl. Arch. f. Zool. Suppl., Band, I.

(133). O. Ridley. *Account of the Zoological Collection made during the Survey of H.M.S. Alert*. Spongiada. Proc. Zool. Soc., 1881, 107. *Sponges of Franz-Josefs-Land*. Ann. Mag. (5), Vol. VII., p. 455.

(134). E. Potts. *Sponges from the neighbourhood of Boston*. Proc. Soc., Acad. Nat., Philadelphia, 1882, p. 69.

(135). W. Haswell. *On Australian freshwater sponges*. Proc. Lin. Soc., N S.W. Vol. VII., p. 208

(136). R. von Lendenfeld (l. c.)

(137). Ch. Chilton. *A New Zealand freshwater sponge*. New Zealand Journal of Science, Vol. I., p. 183.

(138). T. Hilgendorf. *Süsswasser-Schwämme aus Central Africa*. Sitzber. Ges. Nat. Tr., Berlin, 1883, Seite, 87.

(139). W. Retzer. *Die Deutschen Süsswasser-Schwämme*. Tübingen, 1883.

(140). T. Vejdovsky. *Revisio faunae Bohemicae*. Prag, 1883.

(141). E. Metschnikoff. *Spongiologische Untersuchungen*. Z. f. w. Z. Band, XXXII. Seite, 374, ff.

Balfour (142) draws conclusions from F. E. Schultze's observations on the Embryology of *Sycandra*. He considers the Gastrula as a colony of Protozoa, like Haeckel (143) and wishes to separate the sponges from other metazoa, because the functions of Ectoderm and Entoderm in the sponges are not like those in other animals.

Lately the Analogy of the Ectoderm and Entoderm in different Cœlenterata has been found to be very vague, and I have in a series of papers contributed my share to the view that the Embryonic layers in the higher Cœlenterata are equivalent (143a), so that the fact that the Ectoderm of the sponges digests, is not sufficient to warrant that the sponges really are fundamentally different from all other Metozoa, and it is by no means certain, that it really is the Ectoderm that digests.

According to the late most important investigations on this subject, published by Marshall (144) the whole of the inner Epithelia of the sponge are entodermal, and as the digestion certainly goes on *within* the sponge, the digestive surfaces are entodermal.

In the "Stammesgeschichte der Spongien," Zittel (144a) published the classificatory system previously often alluded to, which being based on Palæontology and Zoology alike, deserves our attention. He divides the Spongia into eight groups as follows:—

1. Myxospongiæ. *Haeckel*, without skeleton.
2. Ceratospongiæ. *Bronn*, with horny skeleton only.
3. Monactinellidæ. *Zittel*, with biradiate siliceous spicules.
4. Tetractinellidæ. *Marshall*, with anchor-shaped spicules.
5. Lithistidæ. *O. Schmidt*, with interwoven tetra- or irregular spicules.

(142). F. Balfour. *Morphology and systematic position of the Spongiæ*. Quart. Jour. Micr. Sc., Vol. XIX. p. 103.

(143). E. Haeckel. *Die Gastréatheorie* Jen. Zeitschr., Vol. VIII., p. 1.

(143a). R. von Lendenfeld. *Über das Nervensystem der Hydroidpolypen*. Z. A. Band, VI. Seite, p. 69. *Eucopella Campanularia*. Z. f. w. Z. Band, XXXVIII., S. 497.

(144). W. Marshall. *Die Ontogenie von Reniera filigrana*. *O. Schmidt*. Z. f. w. Z. Band, XXXVII. Seite, 221.

(144a). K. Zittel. *Zur Stammesgeschichte der Spongien* München, 1878.

6. Hexactinellidæ. *O. Schmidt* with hexaradiate spicules.

7. Calcispongiæ. *de Blainville*, calcareous skeleton.

Selenka (145) described a most interesting form of a sponge, which is radially symmetrical; it has eight radii. He studied the development of this sponge, which is the first in which a structure of this kind, corresponding so closely to the Corals, has been observed. (146.)

The Histology of the sponges was particularly investigated by Schulze (l. c.), who published his results in a series of papers between 1875 and 1880. These works, models of accuracy, have proved that the sponges are not Protozoa, with such evidence, that even the staunchest holders of that theory have not tried to oppose this evidence. The conclusive results contained in these essays appear under the heading "Histology."

Keller (147) wishes the sponges to be separated from other Metazoa, but he is far from considering them as Protozoa or colonies of such any more than other animals.

O. Schmidt (148) dwells on the individuality of the sponges, on which question their systematic position of course greatly depends. The views on this subject are the following:—

Carter (149) considers the single cell (Spongozoan) as the individuality, whilst Merejkovsky (150) states that the ciliated chambers should be considered as the individuals. Haeckel (151) and with him most authors were of opinion, that the individuality in the sponges is expressed by the Osculum; any sponge consists of as

(145). E. Selenka. *Über einen Kieselschwamm von ashtstrahligem Bau*. Z. f. w. Z. Band, XXXIII., Seite, 467.

(146). F. E. Schultze described a similar radial structure in other Sponges at the "Versammlung deutscher Naturforscher und Aerzte" in Eisenach, 1882.

(147). C. Keller. *On the systematic position of Sponges*. Ann. Mag. (5). Vol. V., p. 268.

(148). O. Schmidt. *Die Spongien des Meerbusens von Mexico*. Jena., 1880.

(149). H. Carter. *On the nature of the seed-like body of Spongilla*. Ann. Mag. Vol. XIV., p. 97.

(150). C. Merejkovsky. *Études sur les Éponges de la mer blanche*. Mem. Acad. Imp., Petersbourg. Tom. XVI., p. 13.

(151). E. Haeckel. *Die Kalkschwämme*. Berlin, 1872.

many persons as it has Oscula. Practically this theory leads to difficulties, because some sponges have no Oscula, and because similar sponges may have one, or a great many Oscula.

To avoid this difficulty, O. Schmidt (l.c.) expounds a theory according to which the sponges are not personified at all, but are "Zoa impersonalia," or unlimited animals.

EMBRYOLOGY.

The Histology of sponges, as also their Embryology, was not correctly described before Schulze published his observations on that subject.

Metschnikoff (152) disputes the correctness of Haeckel's observations on the Gastrula of *Sycandra raphanus* and states, that the skeletophorous outer side of the sponge is formed out of the round non-ciliated cells which form a plug in the Blastula.

O. Schmidt (153) confirms the observations of Metschnikoff (l.c.), and states that in other cases, besides *Sycandra*, no epibolic Gastrula is formed.

Also Carter (154) confirms Metschnikoff's statements.

In 1877, S. Kent (156) published an account of the development of sponges which differs very much from the descriptions given previously by F. E. Schulze and Metschnikoff. The swarming ciliated gastrula is not a single individual but a "compound ciliated gemmule." The ovum divides by continued fission into a multitude of fringe cells, the fringe of which "has apparently

(152). E. Metschnikoff. *Spongiologische Untersuchungen*. Z. f. w. Z. Band, XXXII., Seite, 349.

(153) O. Schmidt *Zur Orientierung über die Entwicklung der Schwämme* Z.f.w.Z. Vol. XXV, Supplement. Seite 127. *Nochmals die Gastrula der Kalkschwämme*. Archiv. für mik. Anat. Band, XIV., Seite, 249. *Das Larvenstadium von Ascetta primordialis und A. clathrus*. Arch. f. mik. Anat. Band, XIV., Seite, 249.

(154). Carter. *Development of the Marine Sponges*. Ann. Mag. (Series 4), Vol. XIV., p. 321, 389.

(156). Sav. Kent. *Notes on the Embryology of Sponges*. Ann. Mag., Vol. II, p. 139.

been overlooked by other observers," which are exactly like the monads, the spongozoa, which compose the adult sponge. The cells lose their fringes and cilia, and coalesce into a Syncytium, and the sponge soon forms. The embryo does not pass a Blastula stage. Every one of the embryonic cells lives independently as a separate animal through all these stages. The "so called ovum, with amoeboid movement, which, according to Haeckel and others, is the independent product of the *imaginary* entoderm," is an ordinary Spongozoan which has lost its fringe. In a similar way, as the "gemmules" also, the ciliated chambers are formed.

Barrois (157) made some interesting observations on the embryology of different sponges. In most cases the embryo remains solid throughout, and the canal system is formed afterwards in the Mesoderm. He describes the formation of the Morula very accurately. His observations tend to prove the correctness of the previous statements of F. E. Schulze.

Schultze (158) describes the embryology of a great many different sponges. The ovum is fructified within the sponge and divides. No Morula is formed in the calcareous sponges, the stage with sixteen cells is already a Blastula. The Blastula consists of cylindrical small transparent, and rounded intransparent cells; the whole having the shape of an acorn, the intransparent cells forming the cup.

The transparent cells—evidently the Ectodermal elements—are invaginated. The morphological Ectoderm of the so formed Gastrula is physiologically an Entoderm.

The Larva swims about and finally affixes itself by means of pseudopodial processes given off from the Ectodermal cells.

By a complicated folding process the original sac is converted into a large mass traversed by two systems of canals, one being ectodermal and the other entodermal. (Calcispongiae.) In other sponges the process is different.

(157). C. Barrois. *Embriology des quelques Éponges de la manche*. Annales des sciences Naturelles. Zool. VI. ser. III, Art. 9.

(158). F. E. Schultze (l.c.).

Keller (159) published a very interesting account of the early stages of *Chalinula fertilis*, which appears to differ slightly from the corresponding stages described by Schultze of other.

Ganin (160) also augmented our knowledge on this subject.

Marshall (161) published a detailed description of the development of species of *Reniera*. His observations differ from the statements of F. E. Schultze and Barrois (l.c.) The larvæ of *Reniera filigrana* does not pass a *Gastrula* stage, and does not show the apparent anomaly of having the transparent cells inside and the others outside, as Schultze observed in *Sycandra*.

PHYSIOLOGY.

No branch of our science has been so sorely neglected as this one, and to this it should mainly be ascribed that our knowledge of the sponges appears so theoretical. Most of the statements concerning their physiology are deducted from our experience and knowledge of the functions of cells and organs of higher animals, which are similar to those of the sponges.

Metschnikoff (162) and myself (163) have made physiological experiments on the digestion of sponges. I (l.c.) have published some facts on the formation of the slime which sponges produce, and on the sensitiveness of the ectodermal epithelium, and have tried to find out the functions of all the different forms of cells we meet with in the sponges.

Schultze (164) discovered the cells which produce the hornfibres.

(159). C. Keller. *Studien über die Organisation und Entwicklung der Chalineen*. Z.f.w.Z. Band, XXXIII. Seite, 329.

(160). Ganin. *Zur Entwicklung von Spongilla fluviatilis*. Z.A. Band I.

(161). W. Marshall. *Die Ontogenie von Reniera filigrana*. Z.f.w.Z., Band, XXXVII., Seite, 321.

(162.) E. Metschnikoff. *Spongologische Studien*. Z.f.w.Z. Band, XXII., Seite, 371.

(163.) R. von Lendenfeld. *Celenteraten der Südsee Neue Aplysinidæ*. Z.f.w.Z. Band, XXXVIII., Seite, 234.

(164.) F. E. Schultze. *Ueber den Bau und die Entwicklung der Spongien. Die Familie der Spongidae*. Z.f.w.Z. Band, XXXII., Seite, 593.

He (165), Carter (166), Metschnikoff (167), and Keller (168), and others dwell on the formation of the spicules.

PALÆONTOLOGY.

The older ideas about the fossil sponges were partly reformed and partly done away with by Zittel, who made a new classification, and whose essays deserve equal praise for the quantity of new forms discovered and the accuracy of their description, as also for the brilliant deductions concerning the Phylogeny or classification of sponges derived therefrom (169.)

A great many new forms were described by Duncan (170), Sinzow (171), Carter (172), Hinde (173). Wallich (174), Sollas (175), and others.

(165.) F. E. Schulze. *Ueber den Bau und die Entwicklung der Spongien, die Plakiniden.* Z.f.w.Z. Band, XXXIV., Seite 417.

(166.) H. Carter. *Development of the Marine Sponges.* Ann. Mag., Vol. XIV., 321, p. 389.

(167.) E. Metschnikoff. *Spongiologische Studien.* Z. f.w.Z. Band, XXXII., Seite, 349.

(168.) C. Keller. *Studien über Organisation und Entwicklung der Chalcineen.* Z.f.w.Z. Band, XXXIII., Seite, 317.

(169.) R. Zittel. *Ueber Cœloptychium, etc.* Abhandl. Bayer. Akad. Band XII., p. 3, Seite 1. *Studien über fossile Spongien.* Ibid. I., XIII., 1; Ibid. II., XIII., 1, 65; Ibid. III., XIII., 2, 91.

(170.) M. Duncan. *On some spheroidal Lithistid Spongia from the upper Silurian formation of New Brunswick.* Ann. Mag. (5) Vol. IV., p. 84, 91. *On a lithistid Sponge and on a form of Aphrocallistes.* Journ. Lin. Soc., London Zool., Vol. XV., p. 320.

(171.) T. Sinzow. *Ueber Kreideschwämme des Paratowschen Gouvernements.* Denkschr. d. russ. Ges., 6, Band, 1.

(172.) H. Carter. *On Holasterella, a Fossil sponge of the Carboniferous Era, and on the Hemistrella, a new genus of recent sponge.* Ann. Mag. (Series 5), Vol. III., p. 141.

(173.) G. Hinde. *Fossil Sponge Spicules from the Upper Chalk.* Munich, 1880.

(174.) G. Wallich. *A Contribution to the Physical History of the Cretaceous Flints.*

(175.) T. Sollas. *On the structure and affinities of the Genus Protospongia.* Salter. Ann. Mag. (5). Vol. V., p. 238. *On the Flint Nodules of the Trimmingham Chalk.* Ann. Mag. (5). Vol. V., 384, p. 437.

This brief historic introduction has—as far as the older works are concerned—been compiled from Pagenstecher's (175) Historic review, Johnston's (176) introduction to the British Sponges, and particularly from Vosmaer's (177) excellent review of which unfortunately only the first part has at present appeared (178).

Far from being complete, this historic introduction can only serve to enable the student to find the most important works on our subject.

It may, however, be of service also as illustrating the history of science, and indicating the enormous advances made during late years in Zoological discovery.

(175). Pagenstecher. *Zur Kenntniss Der Schwämme. I. Geschichtliche Einleitung.* Verhandlungen. Verein. Heidelberg. Vol. VI. (1872), p. 1.

(176). G. Johnston. *History of British Sponges and Lithophytes.* Edinburgh, 1842.

(177). G. Vosmaer. *Porifera.* Bronn's Klassen und Ordnungen des Thierreiches. Band II., Heft 1, 2.

(178) The whole of that review has appeared whilst this essay was in print, and I refer the reader who wishes to go more into detail, to that publication. (i.e., Heft 3.)